Performance tests of snow-related variables over the Tibetan Plateau and Himalayas using a new version of NASA GEOS-5 land surface model that includes the snow darkening effect

[1,2]Teppei J. Yasunari, [1]K.-M. Lau, [1]Randal D. Koster, [1]Max Suarez, [1,3]Sarith Mahanama, [1]Arlindo M. Dasilva, and [1]Peter R. Colarco.

[1] *NASA Goddard Space Flight Center, Greenbelt, 20771 USA*
[2] *Goddard Earth Sciences and Technology and Research, Universities Space Research Association, Columbia, MD 21044 USA*
[3] *Science Applications International Corporation, Beltsville, MD 20705 USA.*

Abstract

The snow darkening effect, i.e. the reduction of snow albedo, is caused by absorption of solar radiation by absorbing aerosols (dust, black carbon, and organic carbon) deposited on the snow surface. This process is probably important over Himalayan and Tibetan glaciers due to the transport of highly polluted Atmospheric Brown Cloud (ABC) from the Indo-Gangetic Plain (IGP). This effect has been incorporated into the NASA Goddard Earth Observing System model, version 5 (GEOS-5) atmospheric transport model. The Catchment land surface model (LSM) used in GEOS-5 considers 3 snow layers. Code was developed to track the mass concentration of aerosols in the three layers, taking into account such processes as the flushing of the compounds as liquid water percolates through the snowpack. In GEOS-5, aerosol emissions, transports, and depositions are well simulated in the Goddard Chemistry Aerosol Radiation and Transport (GOCART) module; we recently made the connection between GOCART and the GEOS-5 system fitted with the revised LSM. Preliminary simulations were performed with this new system in "replay" mode (i.e., with atmospheric dynamics guided by reanalysis) at 2x2.5 degree horizontal resolution, covering the period 1 November 2005 - 31 December 2009; we consider the final three years of simulation here. The three simulations used the following variants of the LSM: (1) the original Catchment LSM with a fixed fresh snowfall density of 150 kg m^{-3}; (2) the LSM fitted with the new snow albedo code, used here without aerosol deposition but with changes in density formulation and melting water effect on snow specific surface area, (3) the LSM fitted with the new snow albedo code as same as (2) but with fixed aerosol deposition rates (computed from GOCART values averaged over the Tibetan Plateau domain [lon.: 60-120E; lat.: 20-50N] during March-May 2008) applied to all grid points at every time step. For (2) and (3), the same setting on the fresh snowfall density as in (1) was used.

During winter over the Tibetan Plateau and Himalayas, the three simulations performed similarly due to frequent snowfalls that reduced snow darkening at the snow surface. In spring, both Case (2) and Case (3) outperformed Case (1) (compared to MODIS-based snow cover fractions [SCFs]), presumably because the original LSM used maximum snow albedos that were too low, leading to excessive melting. The aerosol depositions used in Case (3) are probably overestimated, since they are based on mean GOCART deposition rates in the pre-monsoon period; even so, Case (3) still outperforms Case (1), indicating that the new snow albedo code improves the treatment of snow processes over the Tibetan and Himalayan regions. On the day of the presentation, we also intend to show additional results that address time-varying aerosol depositions from GOCART on the simulation of snow.